Historical meteor showers - Geminids and December Monocerotids

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Abstract.

Early observations of Geminid and December Monocerotid meteors recorded in the Chinese chronicles are found. Because of their apparitions are at nearly the same time, their identifications of the belonged stream are sometimes uncertain.

The perturbed orbital elements of their parent bodies are calculated, and the meteor trails recorded with fixed stars are examined to identify their streams. Then, a December Monocerotid meteor in AD 381, and a Geminid one in AD 1077 are found as their first historical records. The twenty-nine Chinese meteor records are translated into English, and their estimated trails are given in the star charts.

1. Introduction

It is said that the Geminid meteors were first noted in 1862 (Kronk 1988) and from the orbits of Geminid meteors determined by Whipple (1947), Plavec (1950) calculated the perturbations by Jupiter and found that the intersection point between the orbit of Geminids and the ecliptic in 1700 was placed 0.13 AU inside the orbit of the Earth, and therefore the activity of the Geminids was thought to be decreased before the early 19th century.

Despite this concept, we show here the evidence of the apparitions of Geminids ound in Chinese historical records before the 19th century, and records of the December Monocerotids are also found.

2. Orbit of the parent body and the predicted radiant point of the Geminids

The orbital elements of the parent minor planet of the Geminids, (3200) Phaethon, are given in the Table 1. The basic orbital elements of (3200) Phaethon are newly determined by Nakano (1998) from 271 observations made during 1983 October and 1997 November, and perturbed orbital elements are traced back to AD 120. The effects of the nongravitational forces on (3200) Phaethon are very small, so they are not included.

Although the heliocentric distance of the descending node of Geminids is decreased as shown by Plavec (1950), the separation (Δ) between the orbit of Phaethon and the Earth is not so large. Then, we can expect the Geminids' appearance before the 19th century. According to Hasegawa's method (1990), the prediction of the theoretical radiant point of Geminids is given in Table 1. In

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the first column, selected perihelion passages of the parent comet, nearly every 150 years and the perihelion distance, the eccentricity, the angular elements are given. L is solar longitude at the expected maximum of the meteor shower, and Δ is the separation of the orbit of the parent body and the Earth in the astronomical unit (AU). The predicted coordinates of the radiant point are given in the column under α and δ. All angular values in this paper are referred to the 2000.0 equinox. In the last column, the heliocentric distance of the descending node of the parent body, $r(\mho)$ is given. The mean position of the radiant point of Geminids is shown in Figure 1 by X with Gem.

3. Orbit of Comet Mellish and the predicted radiant point of December Monocerotids

At nearly the same dates of the Geminid meteors, the December Monocerotid meteors are observed. Two Monocerotid meteors were discovered by Whipple (1954), and he suggested Periodic Comet Mellish (1917 I = 1917 F1) as the parent body of the December Monocerotids. Radiant points of the Monocerotids are located at the south of the Geminids' one, and possibility of the existence of ancient Monocerotid meteors is proposed by Fox and Williams (1985) with their discussions on the historical records of fireballs studied by Astapovic and Terenteva (1968).

The orbit of Comet Mellish has not been precisely determined. According to Asklof (1932), the uncertainty of its period is more than half of the year, however, Nakano (1998) traced back the perturbed orbit of this comet to AD 96 to see the general trend of the variation of the orbit. In the Table 2, in the same format as of Table 1, the orbital elements of Comet Mellish and predictions of radiant point of the December Monocerotids associated with this comet are given. In the earlier years, the separation (Δ) of the comets' orbit and the Earth are shorter than those of the Geminids shown in Table 1.

4. Orbits of the December Monocerotid Meteors

In 1985, Ohtsuka and his colleagues observed a December Monocerotid meteor by their cameras, and determined its orbit. Then, Ohtsuka (1988) identified fifteen December Monocerotid meteors observed during 1950 and 1985, and determined the mean position and the motion of the radiant point of Monocerotids as follows:

$$\alpha = 102^\circ.62(\pm 0^\circ.29) + 0^\circ.95(\pm 0^\circ.13)(L - 260^\circ.9),$$
$$\delta = +8^\circ.22(\pm 0^\circ.32) - 0^\circ.03(\pm 0^\circ.15)(L - 260^\circ.9),$$

where L is the solar longitude at the meteor apparition.

Mean orbital elements of the fifteen December Monocerotid meteors are (equinox 2000.0):

$$q = 0.188 \pm 0.012 \text{ AU} \qquad e = 0.991 \pm 0.026$$
$$\omega = 128^\circ.9 \pm 2^\circ.1 \qquad \Omega = 80^\circ.8 \pm 2^\circ.2 \qquad i = 34^\circ.9 \pm 3^\circ.1$$

These values are very similar to the predictions given in the Table 2, so it is certain that the December Monocerotids are associated with Comet Mellish.

Table 1 Orbital Elements of Minor Planet (3200) Phaethon and Predictions of Geminid Meteor Radiants

Epoch = 1998 July 6.0 TT	ω = 321°.83110		
M = 128.19639	Ω = 265.57325	(2000.0)	
q = 0.1397914 AU	i = 22.10429		
e = 0.8900422			

Computed by S. Nakano(1998) from 271 observations during 1983 Oct. and 1997 Nov.

T (TT)	q	e	ω	Ω	i	L	Δ	α	δ	r(☋)
1997 Dec. 31	0.13979	0.89004	321°.8	265°.6	22°.1	262°.4	0.022	114°	+32°	0.879
1985 Feb. 5	0.13958	0.89021	321.7	265.8	22.0	262.4	0.024	114	+32	0.874
1846 Jan. 11	0.13756	0.89180	319.2	268.2	21.1	262.3	0.038	114	+31	0.808
1702 June14	0.13627	0.89302	316.9	270.6	20.3	262.2	0.053	114	+31	0.740
1558 Nov. 20	0.13446	0.89423	314.2	273.4	19.4	262.2	0.067	114	+30	0.676
1415 Apr. 25	0.13310	0.89552	311.1	276.5	18.5	262.2	0.081	113	+30	0.613
1271 July10	0.13163	0.89670	307.7	280.0	17.7	262.1	0.095	113	+29	0.552
1127 Sept. 26	0.13030	0.89769	303.9	283.8	16.9	262.1	0.110	113	+29	0.495
983 Dec. 8	0.12933	0.89849	299.8	288.1	16.1	262.1	0.124	113	+28	0.443
840 Feb. 16	0.12850	0.89915	295.2	292.8	15.5	262.1	0.138	113	+28	0.395
696 Apr. 23	0.12754	0.89989	290.2	297.8	15.0	262.1	0.152	113	+27	0.351
552 June29	0.12689	0.90041	284.7	303.5	14.5	262.1	0.166	112	+27	0.312
408 Aug. 31	0.12671	0.90057	279.0	309.3	14.2	262.1	0.180	112	+26	0.280
264 Oct. 29	0.12638	0.90081	273.3	315.1	14.1	262.2	0.193	112	+26	0.253
120 Dec. 24	0.12622	0.90094	267.3	321.1	14.1	262.2	0.207	112	+25	0.230

Table 2 Orbital Elements of Comet Mellish (D/1917 F1 = 1917 I) and Predictions of Monocerotid Meteor Radiants

Epoch = 1917 April 15.0 TT	ω = 121°.3190		
T = 1917 April 11.1751 UT	Ω = 88.6683	(2000.0)	
q = 0.190186 AU	i = 32.6828		
e = 0.993121			
P = 145.37 years (Uncertainty more than 6 months)			(Asklof 1932)

T (TT)	q	e	ω	Ω	i	L	Δ	α	δ
1917 Apr. 11	0.1902	0.993121	121°.3	88°.7	32°.7	262°.8	0.064	104°	+9°
1774 May 22	0.1871	0.993209	120.9	89.3	32.5	262.7	0.072	104	+9
1631 July 9	0.1863	0.993256	120.4	90.0	32.3	262.9	0.077	104	+9
1487 Jan. 25	0.1911	0.993301	120.0	90.7	32.1	263.8	0.074	105	+9
1333 July 2	0.1963	0.993366	119.1	91.7	31.9	264.7	0.074	105	+9
1172 Feb. 10	0.1960	0.993373	118.5	92.4	31.7	264.8	0.080	105	+9
1020 May 30	0.1923	0.993310	118.4	92.8	31.6	264.7	0.085	105	+9
870 Oct. 21	0.1954	0.993305	117.7	93.8	31.4	265.4	0.087	106	+9
711 Dec. 24	0.1956	0.993336	117.5	93.9	31.3	265.4	0.088	106	+9
557 Oct. 25	0.1923	0.993327	117.7	93.7	31.4	265.0	0.091	105	+9
407 Jan. 27	0.1940	0.993364	117.3	94.4	31.3	265.5	0.092	106	+9
248 Jan. 20	0.1942	0.993376	116.9	94.7	31.1	266.5	0.095	106	+9
96 Apr. 29	0.1912	0.993341	117.1	94.5	31.2	265.1	0.097	106	+9

Table 3 Chinese Historical Records of Geminid and Monocerotid Meteors

No.	Date	L(2000)	Records, Stream and Reference
1	381 Nov. 20	262°.1	Appeared in the SE, flew through Yi(翼) and Zhen(軫) with sound. Mon. p.606
2	839 Nov. 22	260.5	Entered into the seven stars(斗魁). Gem.? p.646
3	1006 Nov. 25	262.8	Appeared at the NE of Zhong-Tai(中台). It was bright and fast with sound. Mon. or Gem. p.656
4	1038 Nov. 25	262.6	Appeared at Dong-Jing(東井), like Venus, red and yellow, with trail, ended near Tian-Lang(狼). Mon. or Gem. p.666
5	1059 Nov. 23	260.1	Appeared at Tian-Lang(狼), flew to the S. Mon. or Gem. p.680
6	1062 Nov. 20	257.3	Appeared at Nan-He(南河) flew to Tian-She (天社). It was bright. Gem.? p.684
7	1076 Nov. 24	261.8	Appeared at the E of Liu(柳), like Venus. Flew fast to the E, blue and white, with trail. Mon. p.706
8	1077 Nov. 25	262.5	Appeared at the N of Tian-Chuan(天船), like Venus. Flew fast to the NW, ended at Teng-She(螣蛇). Red and yellow, with trail. Gem. p.710
9	1082 Nov. 26	263.3	Appeared at the SW of Wu-Ju(五車), like Venus. Flew fast to the NW. Red and yellow, with trail. Mon. p.716
10	1090 Nov. 25	262.2	Appeared at the N of the pole star, like Venus. Flew fast to the N. Blue and white with trail. Gem.? p.723
11	1095 Nov. 27	263.9	Appeared at the S of Zhang(張), like Venus. Flew fast to the SE. Red and yellow with trail. Mon. p.730
12	1096 Nov. 25	262.7	Appeared at the NW of Lang-Wei(郎位), like Venus. Flew fast to the N of Zhou-Ding(周鼎). Red and yellow with trail. Mon. p.732
13	1096 Nov. 29	266.7	Appeared at the N of Liu(柳), like Venus. Flew fast to the W of Xuan-Yuan(軒轅). Red and yellow with trail. Mon. p.732
14	1097 Nov. 27	264.4	Appeared at the N of Wen-Chang(文昌), like Venus. Flew fast to the N of Gou-Chen(鉤陳). Red and yellow with trail. Mon. or Gem. p.734

Table 3 (Continued)

No.	Date	L(2000)	Records, Stream and Reference
15	1163 Nov. 30	266°.6	Appeared at Zhen(轸), like Jupiter. Flew fast to the SE, ended at Qi-Guan(骑官) with trail. Mon. p.745
16	1379 Nov. 27	262.1	Blue and red star flew to the SE from Xuan-Yuan(轩辕), ended at Zhen(轸). Gem. p.768
17	1388 Nov. 26	261.7	Flew from Ce-Xing(厕星) to the SW. Its size was like a cup, red with trail. Gem. or Mon. p.771
18	1402 Nov. 25	260.2	Appeared at Xuan-Yuan(轩辕) and entered into Xia-Tai(下台). Its size was like an egg, blue-white and bright. Mon. p.779
19	1424 Nov. 27	262.5	Appeared at Bei-He(北河). Its size was like an egg, blue and white. Gem. p.810
20	1425 Nov. 25	260.2	At the fifth watch, appeared at Hu-Shi(弧矢), flew to the S. Its size was like an egg, blue-white and bright. Mon.? p.817
21	1430 Nov. 26	261.0	Appeared at Tian-She(天社), flew to the SE. Its size was like a bullet, blue and white, bright with trail. Mon. p.839
22	1434 Nov. 28	263.0	Appeared at Wen-Chang(文昌), flew to the NE. Its size was like an egg, bright and red. Gem. p.855
23	1442 Nov. 26	260.9	Appeared at Shang-Tai(上台), flew to the E. Gem. p.863
24	1459 Nov. 24	258.5	Appeared at Ba-Gu(八穀), flew to the NW, entered into Ge-Dao(阁道). Its size was like a wineglass, blue and white, bright with trail. Gem. p.886
25	1477 Nov. 27	261.9	Appeared at Jing-Xiu(井宿), flew to Tian-Lin(天廪). Its size was like a wineglass, blue and white, bright with trail. Gem. p.901
26	1493 Nov. 27	261.8	At 22 o'clock, appeared at Liu(柳). Its size was like an egg, blue and white. Mon. or Gem. p.910
27	1493 Nov. 28	262.8	At 2 o'clock of the midnight, appeared at Nan-He(南河), flew to the SE. Its size was like an egg, blue and white with trail. Mon. or Gem. p.910
28	1500 Nov. 25	260.0	Appeared at Bei-He(北河), flew to the E, entered into Bei-Dou(北斗). Its size was like a wineglass, red and bright with trail. Gem. p.914
29	1508 Nov. 27	262.0	Appeared at Jing-Xiu(井宿), flew to Xuan-Yuan(轩辕). Blue and white, bright with trail and smoke. Mon. p.919

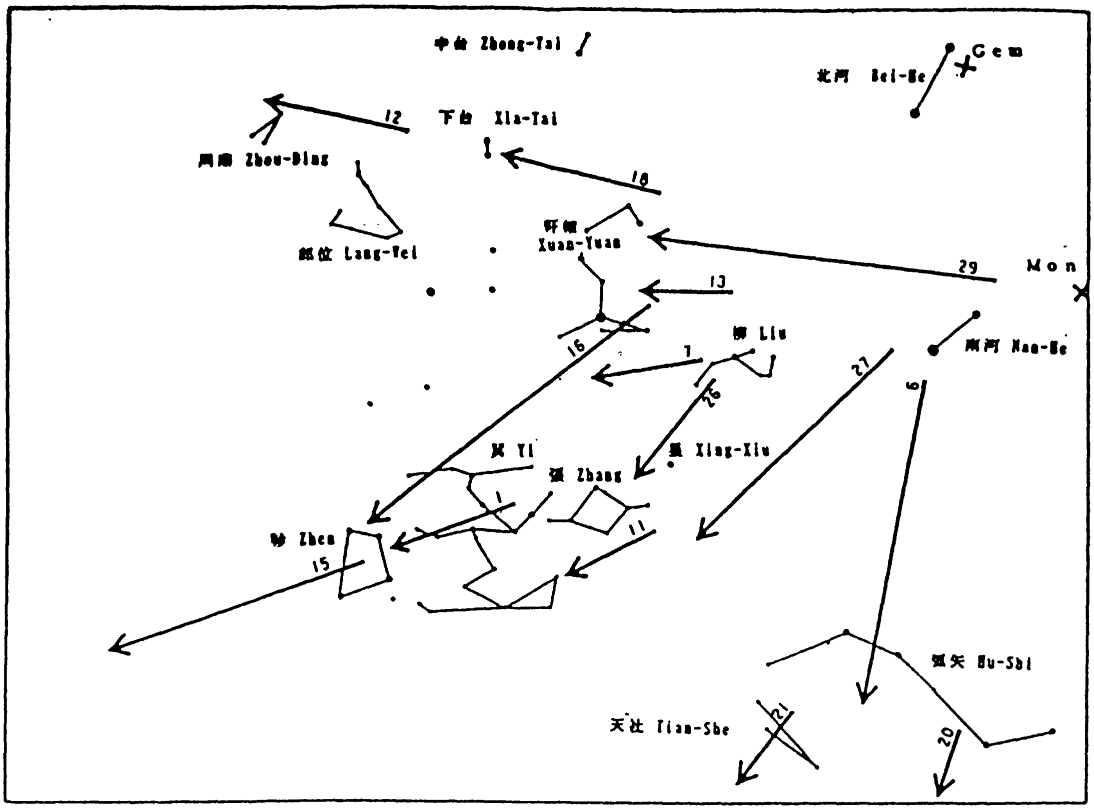

Fig. 1a Meteor Trails of Geminids and Monocerotids in Chinese Records (1)

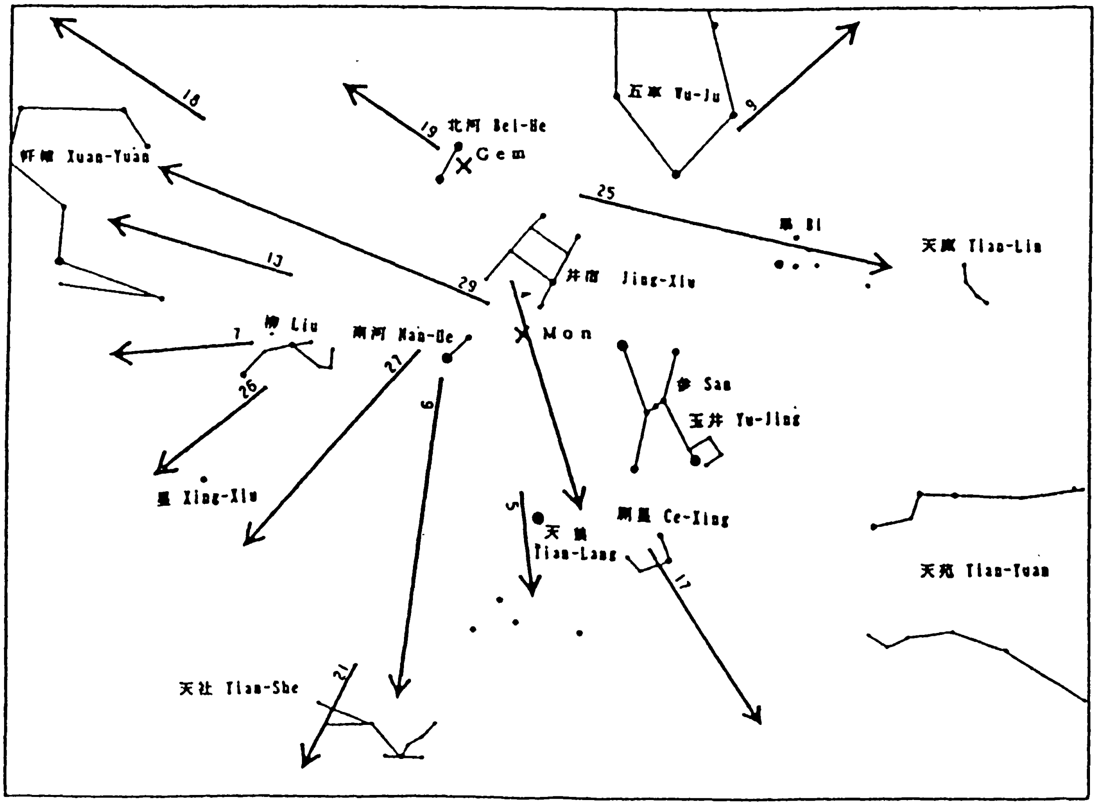

Fig. 1b Meteor Trails of Geminids and Monocerotids in Chinese Records (2)

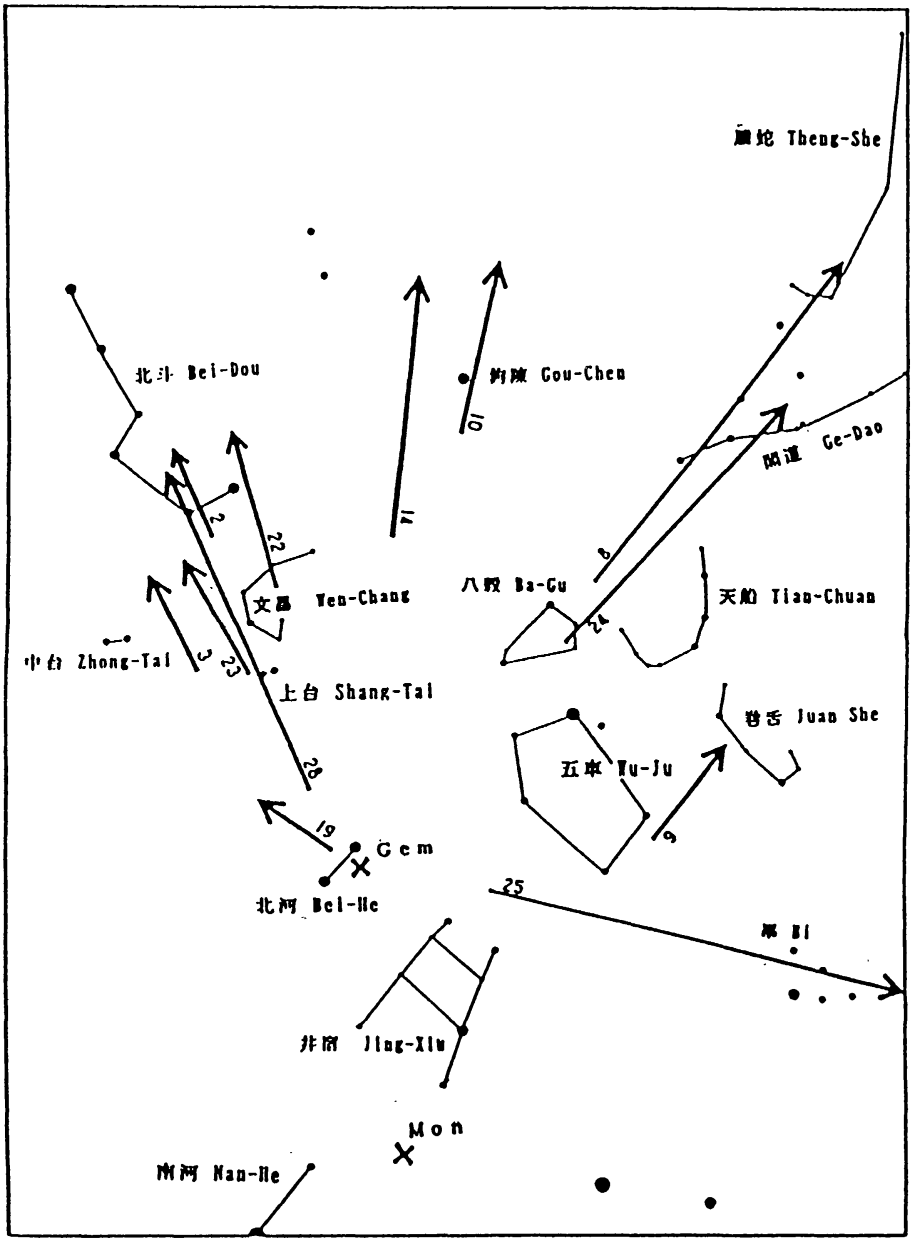

Fig. 1c Meteor Trails of Geminids and Monocerotids in Chinese Records (3)

5. Chinese historical Records of Geminids and December Monocerotids

Most of the Chinese historical records of the bright meteors indicate the meteor trail with Chinese constellations or bright fixed stars and the directions of the path, so we can estimate probable path of meteor. The solar longitude at the time of meteor apparition gives the first criterion of the stream identification of a meteor record. Using the solar longitudes given in Tables 1 and 2, with the possible limits of two or three degrees, we have selected suitable meteor records and have drawn their trails in the star charts to make identifications of the belonged stream. These Chinese records of meteors are translated into English and given in Table 3, and their trails of meteor are shown in Figures 1a, 1b, and 1c. The predicted positions (X) of the radiant points of Geminids (Gem) and December Monocerotids (Mon) are given in these Figures. The numbers attached to the trail are the record numbers given in Table 3. In this Table, the date of meteor apparition, and the solar longitude at the midnight in China on the date are given. At the end of each record, the possible stream name (or names) and the page number of the records in the reference (Beijing 1988) are attached.

The first record of Geminid meteor is in AD 1077, and the one of December Monocerotid meteor is in AD 381. According to Tables 1 and 2, the separations of the orbit of parent body and the Earth are 0.11 and 0.09 AU respectively. The value of 0.1 AU for separation is thought to be reasonable for the prediction of a meteor associated with a comet.

6. Remarks to the Historical Records of Meteor Showers (Hasegawa 1993)

Although the records of Nos. 275 - 282 in the catalogue of historical records of meteor showers (Hasegawa 1993) are denoted as the Geminids, they are not the cases. According to the present study, they are neither the Geminids nor the December Monocerotids, however, they might be a lost stream or the χ Orionids which are given by Kronk (1988) at page 258 in his book. Its maximum comes on December 10 (the solar longitude = 258°), at nearly the same time of Geminids and December Monocerotids.

References

Asklof, S.: 1932, *Ark. Mat. Stockholm, 23, A.* **No.11**, 14

Astapovic, I. S. and Terenteva, A. K.: 1968, in *Physics and Dynamics of Meteors*, eds. Ľ. Kresák and P. M. Millmann, Reidel, Dordrecht, 308

Beijing Observatory: 1988, *General Compilation of Chinese Ancient Astronomical Records (in Chinese)*, Jiangsu

Fox, K. and Williams I. P.: 1985, *Mon. Not. R. astr. Soc.* **217**, 407

Hasegawa, I.: 1990, *Publ. Astron. Soc. Japan* **42**, 175

Hasegawa, I.: 1993, in *Meteoroids and their Parent Bodies*, eds. J. Štohl and I. P. Williams, Astronomical Inst., Slovak Acad. Sci., Bratislava, 209

Kronk, G. W.: 1988, *Meteor Showers*, A Descriptive Catalog, Enslow, Hillside

Nakano, S.: 1998, Unpublished

Ohtsuka, K.: 1988, *The Heavens (Journal of the Oriental Astronomical Association, in Japanese)* **69**, 199

Plavec, M.: 1950, *Nature* **165**, 362

Whipple, F. L.: 1947, *Proc. Amer. Phil. Soc.* **91**, 189

Whipple, F. L.: 1954, *Astr. J.* **59**, 201